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GENERALIZATION OF EXTINCTION ON THE SPATIAL DIMENSION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Generalization of Extinction on the Spatial Dimension" submitted by John Joseph Patrick Kehoe in partial fulfilment of the requirements for the degree of Master of Arts.

ABSTRACT

Recent experiments have demonstrated a "generalization-like" phenomenon with acquisition of voluntary responses in the spatial dimension. The purpose of this experiment was to see whether or not generalization of extinction could also be demonstrated using this same procedure. Twenty Ss were trained to respond to four stimuli (horses) in a horse-race betting situation by probability-matching to the objective win rates of 80% for each of the stimuli. The win rate of the stimulus on the extreme left was then reduced to 20% and the response rates to the three remaining stimuli were examined for the generalized effects of the "extinction" of the extreme stimulus. The probability-matching was fairly successful to all stimuli in acquisition and in extinction with only one S failing to make the discrimination by the end of the last extinction trial block. No generalization of extinction was found since there were no significant differences in the response rates to the three unextinguished stimuli.

An attempt was made to account for the failure to demonstrate generalization of extinction in terms of (1) "frame of reference" phenomenon, (2) position preference, (3) rapid discrimination training, and (4) "prepotent win" effect. The first two explanations were not supported but the third explanation did receive

some support in that there was rapid development of the discrimination between the extinguished and the unextinguished stimuli. It was suggested that the continuation of trials to the unextinguished stimuli might have made possible a very rapid discrimination which would have obscured a transitory generalization phenomenon in the grouped data. Finally, the possibility was suggested that the phenomenon simply might not exist with the horse-race betting situation because of the nature of the probability-matching task and S's manner of construing a win.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Introduction

<u>Stimulus generalization</u>

Stimulus generalization refers to the empirical phenomenon in which a response, previously trained to be elicited by a particular stimulus, is also elicited by a similar stimulus. A gradient of stimulus generalization is said to be observed if the strength of the generalized responses varies as an orderly function of the psychophysical difference between the original training stimulus and the test stimulus (Mednick & Freedman, 1960).

Defined in the above manner, the concept of stimulus generalization refers only to the empirical fact that a transfer of training has occurred. Often the term is used, deliberately or otherwise, to indicate underlying processes or mechanisms that are believed to determine the overt behavior, e.g. spread of cortical excitation, excitation of common sets of neural pathways, or failure to discriminate completely between the original and the generalized stimulus. Frequently it is used in both the empirical and theoretical sense without distinction, and even when used in the empirical sense, different writers may be referring to fundamentally different phenomena since stimulus generalization has been demonstrated under a variety of conditions and using a number of procedural variations.

The first laboratory demonstration of stimulus generalization was by Pavlov (1927), whose neurophysiological

theory made extensive use of the phenomenon. According to him, excitation at a point on the cerebral cortex "irradiates" over the whole surface and will be concentrated at any other focus of excitation. With repetition of two stimuli in a particular time sequence, the excitation aroused by the neutral member (conditioned stimulus, CS) is drawn into the focus of the unconditioned stimulus (UCS) in sufficient strength to elicit the conditioned response (CR), which resembles the unconditioned response (UCR). The phenomenon of generalization was predicted from the assumption that excitation aroused by a stimulus similar to the CS would also irradiate and be drawn into the focus of the UCR. Since isomorphism to stimulus dimensions was postulated for the cortical analyzer, and since the irradiation process was presumed to diminish in intensity as it spread over the sensory cortex, it was expected that the more remote the generalized stimulus from the focus of the CS, the weaker would be the strength of the generalized CR.

The actual technique for obtaining stimulus generalization was first described by Anrep (1923). Typically, a response was conditioned to the tactile stimulation (CS) of a location on a dog's body. Measures were then taken of the strength of the same response to stimulation at other points on the animal's body. Systematic gradients

of stimulus generalization were commonly observed, with the strength of the response decreasing as a function of the distance from the location of the original conditioning, as Pavlov's theory predicted.

Essentially the same experimental procedure was used in disproving Pavlov's theory. Grant and Dittmer (1940) using human Ss, demonstrated that the gradients for the Galvanic Skin Response (GSR) conditioned to tactile CS's on the back and on the hand were essentially equal in slope, despite the fact that the cortical representation for equal distances on the hand is much larger than for the same distances on the back. Had Pavlov's theory been correct, a steeper gradient should have been obtained for the hand than for the back. Moreover, Bass and Hull (1934) found similar-appearing gradients from stimulation of points from shoulder to back, back to thigh, and thigh to foot, while in the cortical representation of these areas the thigh, calf and foot are interpolated between the waist and buttocks. Further evidence against the theory is provided by demonstrations of stimulus generalization in dimensions for which spatial cortical representation is neither known nor even hypothesized. Generalization has been observed in such dimensions as frequency of tone (Hovland, 1937a), intensity of tone (Hovland, 1937b), hue (Guttman & Kalish, 1956), intensity of direct and indirect light

(Spiker, 1956; Raben, 1949), temporal stimulus patterns (Czehuru, 1943), size or area (Grice & Saltz, 1950) and angularity (Butter & Guttman, 1957), none of which dimensions require a spatial cortical representation assumption for their explanation.

Despite the shortcomings of his theoretical position, the technique for studying generalization developed by Pavlov and his colleagues has remained the basic model. In practice, however, it has been found that a number of procedures departing markedly from the basic model are still capable of producing "generalization-like" phenomena. For example, while the Pavlovian technique used only classical conditioning procedures for establishing the original CR, subsequent studies have employed operant or instrumental conditioning, and some have even used verbal instructions in the place of conventional conditioning procedures. Instrumental conditioning introduced the practice of using periodic or intermittent reinforcement during the initial training rather than pairing each presentation of the CS with the UCS as is done in the classical conditioning design. The development of a generalization gradient was not impeded by this procedure and, in fact, it proved to have some advantages over the classical conditioning design.

A procedure resembling partial reinforcement has been employed in studies using voluntary rather than

conditioned responses. In some cases, the _S_s were actually told the reinforcement schedule of the original stimulus; in others, the _S_s had to "learn" the schedule in a process of probability-matching.

Another area of fundamental difference in generalization studies is in the nature of the independent variable, the continuum on which the generalization is presumed to occur. Pavlov used the physical dimension of frequency of tone, without regard to the _S_'s perception of tone, in his experiments in the auditory dimension. Hovland (1937a, 1937b), on the other hand, employed psychophysical scaling techniques to make the dimension psychologically meaningful. In addition, some writers (Lashley & Wade, 1946; Evans, 1961) have argued that _S_s must have prior exposure to the range of test stimuli in order for a systematic gradient of generalization to appear, or even that differential reinforcement is required to make the dimension relevant for the subject and to provide a "frame of reference." Others (Ganz & Riesen, 1962) have demonstrated that for at least some continua and for some animals no such prior experience is necessary. Some experimenters thus expose the _S_s to only one stimulus prior to generalization testing, while others expose them to other stimuli in the test range and in some cases deliberately present discrimination training trials. The Pavlovian procedure usually involved training at only

one stimulus position.

Procedural departures extend to the testing procedures and the measurement of the generalization of the response. Some studies, for example, used separate groups which were tested at each stimulus value while others tested each _S_ at each value, as was the practice in Pavlov's experiments. Again, measurement of generalization may be taken on the first test trial or it may be the mean of a block of test trials at any stage of extinction. The response measure itself may be rate, latency or amplitude, depending upon the nature of the response, and in some cases, two measures may be used for the same behavior.

Despite the differences in the methods used to generate the gradients and in the response measures employed, there have been attempts to generalize formulations derived from one conditioning procedure to radically different situations (Mednick & Freedman, 1960). The question arises as to whether or not the various designs meet the empirical definition, and if they do, whether or not conclusions drawn from one conditioning situation can be applied to another regarding the phenomenon of stimulus generalization.

Spatial generalization with voluntary responses

The use of voluntary rather than conditioned responses is perhaps the most dramatic departure from the Pavlovian technique for studying spatial generalization. Gibson (1939) was the first to use voluntary responses for this purpose and she acknowledged the difference by describing the results of her experiment as a "generalization-like" gradient. Her procedure was basically the same as that used by Bass and Hull (1934) in the study referred to previously. They conditioned the GSR in humans to a vibratory tactile stimulus and tested for degree of generalization by applying identical vibrators at other positions. Whereas their study employed GSR conditioning to shock, Gibson simply instructed her Ss to utter a nonsense syllable when they thought the tactual-vibrator was being applied to the original point on their body and to say nothing when it was applied to other points. Her results using this procedure were comparable to those of the Bass and Hull study.

Brown, Bilodeau and Baron (1951) extended the voluntary response technique to the visual-spatial dimension. Seven equally-spaced lamps were arrayed in a horizontal plane equidistant to S, and the Ss were instructed to respond by releasing a reaction-time key whenever the middle lamp was lighted but to ignore any other lights that might come on. Following a series of "conditioning"

trials with the middle light only, the peripheral lights were presented randomly, interspersed among continuing presentations of the middle light. It was found that subjects made "false" responses to the prohibited lights in inverse proportion to their distance from the middle lamp. From these results they concluded that a phenomenon paralleling the generalization of conditioned responses had been demonstrated, and that there was "little reason for supposing that the basic phenomenon was unique to these [classical conditioning] procedures" (p. 56). The authors treated stimulus generalization as strictly an empirical phenomenon and are credited with being among the first to do so (Prokasy and Hall, 1963, p. 314). By approaching the phenomenon in this way, they focused attention on the conditions under which generalization could be expected to occur and helped draw the distinction between generalization as a theoretical construct and generalization as an empirical phenomenon.

Brown, Clark, and Stein (1958) used a variation of the preceding procedure which departed even further from the conventional conditioning paradigms. The method involved essentially the same apparatus, but now the subjects were in a simulated horse-race-betting situation where the seven lights represented seven horses and the _S_'s task was to predict the outcome of each horse's race. The lighting of a lamp represented a horse running in a

race. The subject was required to bet on the outcome of the race and was informed of the result by a visual display. The middle horse in fact "won" 80% of its races; all others "won" only 20% of their races.

This procedure produced fairly symmetrical, bidirectional gradients of spatial generalization with the gradients appearing to be even steeper than those produced by the reaction-time technique. An interesting feature of this procedure was the finding that despite the fact that 6 of 7 lights (horses) won only 20% of their races, there was no evidence of a suppressing or inhibiting effect on the win-betting to the central light which objectively won 80% of its races. Dixon and Wickens (1961) concluded that the Ss "would rather win by betting on a winner than a loser" (p. 510).

The utility of the horse-race-betting technique was further demonstrated in a nonspatial dimension by Bass (1958). She used four silhouettes of horses differing only in degree of greyness. Each horse was presented in random order in exactly the same position by means of a slide film projector. Three horses won 40% of their races; one won 80% of its races. Subjects were tested beforehand for their ability to discriminate between the four horses. Two groups were used, one in which the darkest horse won most often, and one in which the lightest one did. Gradients comparable to those obtained by

classical conditioning procedures were obtained for both groups and were interpreted as reflecting the presence of "generalized reactive tendencies."

The use of voluntary rather than conditioned responses is so great a departure from the more conventional procedures as to make comparisons between them very difficult. Variables that appear to be important in determining the gradient in one situation are seemingly unimportant, or even absent, in the other. The need for prior exposure to the range of stimuli is a case in point. Several opinions are found in the literature. Among the studies using instrumental conditioning techniques, there is the contention that, in some cases, generalization follows automatically from the physiological properties of the receptor system (Ganz & Riesen, 1962), but that in other cases the development of a "frame of reference" is necessary. Friedman (1963) suggests that the "frame of reference" hypothesis may be inapplicable to qualitative continua, and both he and Peterson (1962) suggest that it may be inapplicable to animals below a certain level on the phylogenetic scale because they are simply incapable of using the information provided by a series of test stimuli. In the case of the voluntary response design using probability-matching ("horse-racing") the evidence is clear (Evans, 1961; Brown et al., 1958). The stimuli, according to the analysis of Grant, Hake

and Hornseth (1951), are not lights or horses, but rates of positive (win) trials. As such, they do not exist in space until the training trials assign them to the spatially arrayed stimulus lights. Training to only one stimulus value would not be expected to produce a reasonable gradient. Prior exposure to the entire range is necessary.

Another variable which has a differential effect in voluntary as compared to conventional conditioning procedures is the amount of training. This variable has been found to differentially effect the shape of the gradient. Margolius (1955), using an instrumental conditioning design with rats, found that the height of the generalization gradient was a direct positive function of the number of reinforced trials to the training stimulus. White (1965), using a voluntary response, and Brown et al., (1951) using the reaction-time technique, found that increasing the number of training trials slightly decreased the incidence of generalized responses. The same would logically be true of the horse-race-betting technique employed by Brown, et al. (1958) since the most further training trials could be expected to do would be to increase the slope between the 80% and 20% "winners."

Nakamura and Kaswan (1962) present a theoretical argument against generalizing from one type of study to another based upon Gibson's (1959) distinction between primary and secondary stimulus generalization. Gibson

interprets primary stimulus generalization as essentially an inability to discriminate between stimuli. Secondary generalization is thought to involve mediational processes, perhaps categorization (Mednick & Freedman, 1960; Nakamura & Kaswan, 1962). It is suggested that the reason for the lack of agreement between studies using classical and instrumental conditioning, as opposed to those using voluntary responses is that the conditioning studies were in large part concerned with primary stimulus generalization and the voluntary response studies with secondary generalization.

Despite the differences between them, the voluntary response technique has been used in situations that appear to meet the demands of the empirical definition with essentially the same results as those using conditioned responses. The method has been used in investigations of learning phenomena (Bilodeau, Brown and Meryman, 1956) and in explaining the behavior of brain-damaged and schizophrenic individuals (Mednick, 1955). The advisability of drawing generalizations from studies using the voluntary response technique and applying them to situations involving other types of conditioning is, of course, a function of the degree to which this method is comparable, at least in terms of empirical findings, to the other methods of investigating generalization.

<u>Generalization of extinction</u>

The generalization of extinction is a phenomenon that was predicted and observed in the earliest generalization studies. Pavlov (1927), Hovland (1937a) and Bass and Hull (1934) included tests for generalization of extinction in their studies of generalization. In the classical generalization of extinction design, conditioning was carried out equally on a series of values along a generalization continuum. Once a baseline of responding was established, one of the stimuli was presented for a number of consecutive trials without the presentation of the UCS, permitting experimental extinction to that stimulus to occur. The original stimulus series was then presented again, this time without the UCS being given for any of the stimuli. Usually each subject was tested on each stimulus of the generalization series, but in some designs separate groups were tested at each value. The typical gradient resulting from this procedure showed increasing response strength as a function of increased distance from the extinguished stimulus.

Pavlov (1927) used such a design in one of the first demonstrations of generalization of extinction. A salivary reflex to acid was conditioned to tactile stimulation along one side of a dog's body. The reflex was equalized for several points so that the dog responded equally to stimulation along the whole of the surface of one side

of the body. A point was then selected as the extinction locus and the tactile stimulus was applied repeatedly without reinforcement until experimental extinction had occurred. The response was then tested at various other points along the dog's body. Pavlov found that the response at these other points was reduced ("suffered inhibition") to a greater or lesser extent depending upon the distance of the stimulus from the originally extinguished stimulus.

In another series of experiments, Pavlov (1927) employed essentially the same design but with auditory stimuli. Tones of 132, 123, 1036 and 1161 c.p.s. were used as well as a hissing sound and the beat of a metronome. Separate and equal conditioned alimentary reflexes were established to each of the stimuli. In the course of the experiment, one of the conditioned reflexes was extinguished to zero level of responding by presenting it without the UCS. The remaining reflexes were tested at various intervals of time ranging from immediately to 15 minutes after the extinction of the stimulus. All points showed a decrement, and a gradient was observed in that the more similar the stimulus to the extinguished one, the greater and longer lasting the effects of the extinction to the first stimulus.

The study by Bass and Hull (1934) was designed primarily to replicate with humans the work of Pavlov

and Anrep and to clear up doubt about the statistical significance of their findings. The design followed very closely that described by Pavlov in his study with dogs. Tactile stimulators were cemented to the subject's skin at each of four evenly spaced stimulus points about 16 inches apart along the back of the subject's body. As in that part of the study investigating generalization in acquisition, these positions corresponded approximately to the shoulder, small of the back, middle of the thigh and the left calf. The UCS, mild electric shock, was delivered to the right wrist; the CR and UCR was the GSR on the left hand. The four stimulus points were conditioned to a uniform level of responding and a single stimulus at the extreme was then extinguished to approximately one-fourth of its original strength by repeated presentations of the CS without the UCS. The strengths of the remaining stimuli were then tested over a period of several days. A procedural difficulty arose in that all of the non-extinguished responses had to be re-established by occasional reinforced trials because of the length of time involved in taking the generalization measures. Despite this problem, which would result in some discrimination training, a positively decelerated gradient of response strength was obtained. Bass and Hull concluded that they had found a definite "spread of inhibition" resulting from experimental extinction.

Hovland (1937a) used an almost identical design to study generalization of extinction of response to auditory stimuli, the major differences being that he used frequency of tone as the CS and a psychophysical rather than a physical scale for the generalization continuum. Adjacent tones, 25 j.n.d.'s (just noticeable differences) apart were used and GSR was again used as the CR and UCR. Conditioned responses were established to four tones; responding to one tone at the extreme was extinguished; and responding was then tested at the other points. A gradient was obtained which resembled that obtained in the Bass and Hull (1934) study.

Recently, much attention has been given to the generalization of extinction of instrumentally, in contrast to classically, conditioned responses. The earliest studies of this kind simply demonstrated that the extinction of one bar-pressing response facilitated the extinction of a second such response (Youtz, 1939; Ellson, 1938). Thompson (1950) specifically studied the generalization of extinction using instrumentally conditioned responses. His aim was to investigate the form of the "gradient of inhibition" of an instrumental response to stimuli varying in the visual size dimension. Twenty-seven rats were trained to obtain food by opening doors in the centers of four white circles with areas representing equal log steps and measuring 20, 32, 50 and 79

square centimeters. Equal habit strength, as measured by latencies in running a straight alley to the circle, was established to all four circles. The responses to the 20 sq. cm. circle were then extinguished for half of the animals and to the 79 sq. cm. circle for the others. Each animal was given multiple tests with the other stimuli to determine the effects of the extinction procedure on responding to the other circles. He found gradients of latency for both groups that approximated negative growth functions.

Kling (1952) replicated this experiment, but made some methodological changes in order to overcome a weakness in previous studies, including Thompson's (1950). Despite attempts to minimize it, differential reinforcement had, in fact, been given in most of the previous generalization of extinction studies in the form of reinforced trials interspersed among the generalization trials. The effect should be to sharpen the gradient, and the result, it was argued, should be termed a "discrimination gradient," (Hull, 1950). Whereas Grice and Saltz had attempted to overcome the difficulty by testing each animal on one stimulus only, Kling attempted to maintain the alley-running habit during the extinction trials by periodically presenting a black square which was always reinforced in place of the white circle in both the training and extinction trials. As a second

procedural variation, Kling employed separate groups so that each animal was trained only on the stimulus to be extinguished, the stimulus to be tested, and, in all cases, the black square. The form of the composite gradient was similar to previously derived gradients of generalization of extinction. Honig (1961) pointed out, however, that a discrimination was necessary in order for the procedure using the black square to have the desired effect, and although along another dimension, discrimination training was still a part of the procedure.

Honig (1961) used an operant conditioning technique which he hoped would obviate the seemingly inevitable discrimination training during the testing trials. The pre-extinction test without reinforcement at all training values, which was necessary to determine baseline level of responding, could be obtained from the rates of responding during the training itself; because of the use of partial reinforcement, extinction could be carried on much longer without the need for retraining and re-extinction; and each animal could be tested at each stimulus value, thus avoiding the problem of having to form composite gradients from independent groups.

The procedure involved training pigeons to key-peck on a variable interval (VI) reinforcement schedule to each of thirteen stimuli along the hue dimension. Once the habit was established, the pigeons were divided

into three groups. One group was extinguished at one stimulus value, the middle one, for 40 consecutive minutes, a second group was extinguished at the same value for 80 minutes, and a third group, a control, received no extinction at all. Only the one stimulus value was presented during the extinction trials. Generalization testing was conducted on the days following by presenting the stimuli in a manner similar to the VI training but without reinforcement. Reconditioning and retesting were also carried out to study the effects of retraining on the gradient. No extinction was used between the retraining and retesting. The data for the generalization of extinction tests showed a clear decremental gradient around the extinguished stimulus point for both experimental groups. The gradients for the second day of testing were flatter but still showed the effects of extinction of the one specific value. The gradient from the control group was flat but lower than the baseline, reflecting extinction at all stimulus values perhaps due to the presentation of the stimuli without reinforcement during the testing. The retraining and retesting data continued to show the effects of the generalization of extinction at the extinguished stimulus value despite the fact that the retraining brought the gradient above the previously established baseline.

Honig compared his results with a previous study (Honig, Thomas & Guttman, 1959) which had failed to find

a differential effect of uninterrupted extinction trials at one value on the subsequent responding to other test stimuli. The earlier study had found that instead of a differential decrement in responding, the whole gradient was reduced by a constant proportion, whereas with successive discrimination training, responding was reduced specifically in the area of the unreinforced stimulus and the mean of the gradient was shifted away from that value. Honig attempted to account for the difference between his findings and those of the earlier study by suggesting that his gradients were not primary gradients of extinction at all. He proposed that the gradient he obtained was a composite of the gradients of acquisition around the different training values, which had been differentially reduced by the extinction procedure. This interpretation assumes that each stimulus value shares some of the response strength of adjacent stimulus values due to generalization of acquisition. Extinction at any one value reduces the response strength at the other values by the amount that its response strength had generalized in acquisition to these other stimuli. Honig drew some support for his position from the fact that all previous studies reporting gradients of generalization of extinction had presented more than one stimulus prior to testing for generalization. Generalization of extinction in Honig's analysis does not assume an active inhibitory

process diminishing in strength with distance from the extinguished stimulus, but simply the reduction of a learned habit irrespective of the extinguished stimulus.

Honig's position can be contrasted with that of Spence (1937) and Hull (1952), who postulated from their observations that gradients of extinction (inhibition) not only exist but are of the same form as the gradients of acquisition, though inverted. This assumption was fundamental to Hull's theory of discrimination learning, which saw discrimination behavior as the result of the interaction between gradients of acquisition and extinction. Hull drew support for his position mainly from the classical conditioning studies of Pavlov (1927), Bass and Hull (1934), and Hovland (1937a), but later studies such as those by Thomson (1950) and Kling (1952), using instrumental conditioning, have also supported this position.

Purpose

Post-extinction gradients of generalization of extinction have been observed in experiments employing both classical and instrumental conditioning paradigms and their existence has assumed considerable theoretical importance. Generalization in acquisition has been observed using classical and instrumental conditioning with both human and infrahuman Ss and it has been observed with human Ss in a variety of voluntary responses:

instructed (Gibson, 1939), reaction-time (Brown et al., 1951) and probability-matching (Brown et al., 1958). Generalization of extinction has also been observed in classical and instrumental conditioning paradigms with both human and infrahuman Ss. Since it has not been observed in the voluntary response paradigm, it was the purpose of this study to attempt to demonstrate the generalization of extinction of a voluntary instrumental response on the basis of spatial localization of identical stimuli. The voluntary response selected was probability-matching in a "horse-race" betting situation.

METHOD

Subjects

The Ss were 20 volunteer undergraduate students enrolled in Introductory Psychology at the University of Alberta. There were 11 males and 9 females. The Ss were screened on the basis of hand-dominance only, right-handed Ss being required because of the structure of the apparatus for indicating responses.

Apparatus

The apparatus used was a modification of that described by Brown et al. (1958) and was essentially the same in function. The primary difference was that whereas their apparatus consisted of seven stimulus lights, representing seven horses, the present study used only four stimuli consisting of silhouettes of horses, which could be illuminated from behind. The silhouettes were mounted at equal intervals on the horizontal midline of a black backboard, the dimensions of which were 6 ft. long by 2 ft. high. The backboard was at eye level and had a slightly concave bend in order to improve visibility for the Ss. The stylized horse silhouettes were 7.5 in. long by 4.5 in. high (See Appendix A). They were spaced 16 inches from center to center and were all facing to S's left for all trials. Only one horse was illuminated at a time, and when not illuminated,

the silhouettes were not visible because of a translucent plastic screen in front of each. The position of each horse was obvious to the Ss at all times. Illumination was provided by 6 w. lamps mounted behind each silhouette. Directly above the center of the backboard and above the line of horses were two signs, the upper one reading "win" and the lower one reading "lose." The signs were in 2 in. high block letters and were illuminated from behind in the same fashion as the horses. Order of presentation of the horses and the outcome signs ("win," or "lose") were controlled by an automatic programmer.

Five desks were arranged in a slight semicircle approximately 13 ft. from the stimulus panel. The desks were 22 in. by 24 in. by 30 in. high and were separated by partitions so that only the desk and the stimulus panel were visible when S was seated. On each desk was a response box 16 in. long by 9 in. deep and sloping toward S so that S's hand could rest comfortably at the response switch. On the left-hand side of the box were two signs identical to the outcome signs on the stimulus panel but half their size. These signs were likewise visible only when illuminated from behind. On the right side of the box was a double-pole switch which permitted three positions. The "up" position, away from S, illuminated the win sign on the response box; the "down" position illuminated the lose sign. Between these positions

was a neutral position in which neither was illuminated. The response boxes were so wired that all five switches had to be in a bet position, i.e. win or lose, before the automatic programmer would step to the next event, which was a delay followed by the presentation of the "outcome."

Hunter Timers controlled the length of the ready signal, the delay preceding the presentation of the outcome, and the length of the outcome itself. The ready signal was automatically sounded for 2.0 sec. and consisted of a 6 v. bell with a muted clapper. The delay of 1.0 sec. after all _S_s had responded was followed immediately by the illumination for 2.5 sec. of the appropriate outcome sign on the stimulus panel. The termination of the outcome sign was followed by the ready signal and the sequence was repeated. The _S_'s responses (bets) were recorded on an Esterline-Angus event recorder which provided for the recording of (a) "Win" bets, (b) "lose" bets, (c) onset of ready signal and (d) order and duration of the appearance of each horse. The response of the _S_s appeared as a step-wise mark on the record paper for as long as the switch was in a bet position.

The experimental room was 15 ft. by 16 ft. and the only illumination was from the overhead fluorescent room lamps and the apparatus lights described above. _E_ was situated at the front of the room in reach of the programming and recording apparatus but out of view of the _S_s.

Procedure

The Ss were tested five at a time, each seated at one of the desks and out of the sight of the others. Except for the audible clicks of the response switches and recording pens, the Ss could know nothing about each other's responses. Instructions were given in the use of the switches and the Ss were given three practice trials. Following the suggestion of Brown et al. (1958), emphasis in the instructions was laid on thinking of the horses as racing independently of one another.

Instructions to Subjects

E. On the box in front of you is a switch that moves into three positions: 'Ready,' the position it is in now, up and away from you, and down, or toward you. Pushing the switch up will light up a 'win' sign on the box; pushing it down will light up a 'lose' sign. In the 'ready' position there should be no lights on. Try it in each of those positions a couple of times and then return it to the 'ready' position.
Make sure you put the switch fully into position each time.
Now, each of the horses in front of you, like the one you see lighted here, represents a real horse that is going to be in a race. When a particular horse lights up, it means that that horse is at that moment running a race against other horses on an imaginary track. Notice....the horse is not racing against the other horses on the board, but against other horses not represented here. In fact, you should think of each of the horses as racing at different race tracks across the country. How any one of the horses does on its particular race has nothing to do with how the other horses on the board are going to make out on their races. Nor does your bet effect the outcome. The results of each race are predetermined and programmed on tape.

The object of this experiment is to see how well people can make predictions in the horse-race betting situation. All you have to do is predict on each race whether or not the horse that lights up is going to win its race. If you think it will win, push your switch forward and the 'win' sign on the box will light up; if you think it won't win, push the lever down and the 'lose' sign will light up. Then the correct answer will appear on the board, just above the horses. You can take as much time as you need to place your bet. At first you will just have to guess, but as you get to know the horses, your betting should improve on the basis of your past experience with each of them.
Are there any questions?
Let's try a few. Place your bets on this horse. Now leave the switch in position until you see the results of the race and until you hear a buzzer; when you hear the buzzer, return your switch to the ready position.
I'll demonstrate.
Here is the outcome of that race.
While the buzzer was sounding, you should have returned your switch to 'ready'. If you turn your switch to 'ready' before you hear the buzzer, the same horse will light up again and you will have to re-place your bet.
Are there any questions?
Place your bets on this horse.
Now try this one.
Now this one. Are there any questions before we begin?
Place your bets.

The trials were divided into nine blocks of 20 each. Within each block, each horse was presented five times in random order with a different order being used for each block. The only constraints on the randomizing of the presentation of horses were: (1) no horse should be presented more often than any other, (2) every horse should follow every other horse approximately the same number of times, and (3) no horse should appear on more

than two consecutive trials. The same order of presentations and trials was used for all groups of Ss (See Appendix B). The first four trial blocks (20 trials per horse) constituted the conditioning or training trials in which the actual win-lose schedule had all four horses winning 80% of their races. The next five trial blocks constituted the generalization of extinction test trials in which three of the horses continued to win 80% of their races, but the horse on the left end (i.e. horse #1) won only 20% of its races.

RESULTS

Mean percentage "win" responses for each of the nine trial blocks for each horse are shown in Table 1 and Fig. 1. The mean percentage "win" response is plotted separately for each horse for training trial blocks in Fig. 2 and for extinction trial blocks in Fig. 3. The data for trial block 9 are omitted in Fig. 3 for ease of reading, but

Table 1

Mean and Standard Deviation of Percentage "Win" Responses for Each Trial Block

Trial Block	Horse Number 1		2		3		4		Grand Mean*
	$\overline{X}$	(S.D.)	$\overline{X}$	(S.D.)	$\overline{X}$	(S.D.)	$\overline{X}$	(S.D.)	
1	57	(21.2)	57	(21.2)	46	(27.6)	49	(27.2)	52.2
2	74	(23.7)	70	(29.3)	45	(31.5)	73	(23.9)	65.5
3	72	(22.3)	71	(14.8)	65	(28.9)	75	(27.5)	70.8
4	70	(21.4)	80	(23.7)	76	(20.6)	65	(18.8)	72.8
5	77	(21.2)	78	(19.9)	73	(26.3)	81	(24.9)	77.3
6	45	(26.0)	83	(21.2)	74	(22.9)	70	(20.5)	75.7
7	39	(27.2)	75	(25.2)	80	(21.0)	80	(22.8)	78.3
8	31	(27.2)	81	(18.4)	81	(19.5)	86	(16.9)	82.7
9	33	(24.7)	80	(24.5)	77	(23.9)	82	(17.8)	79.7

*Grand Means for block 5 through 9 exclude data for horse #1.

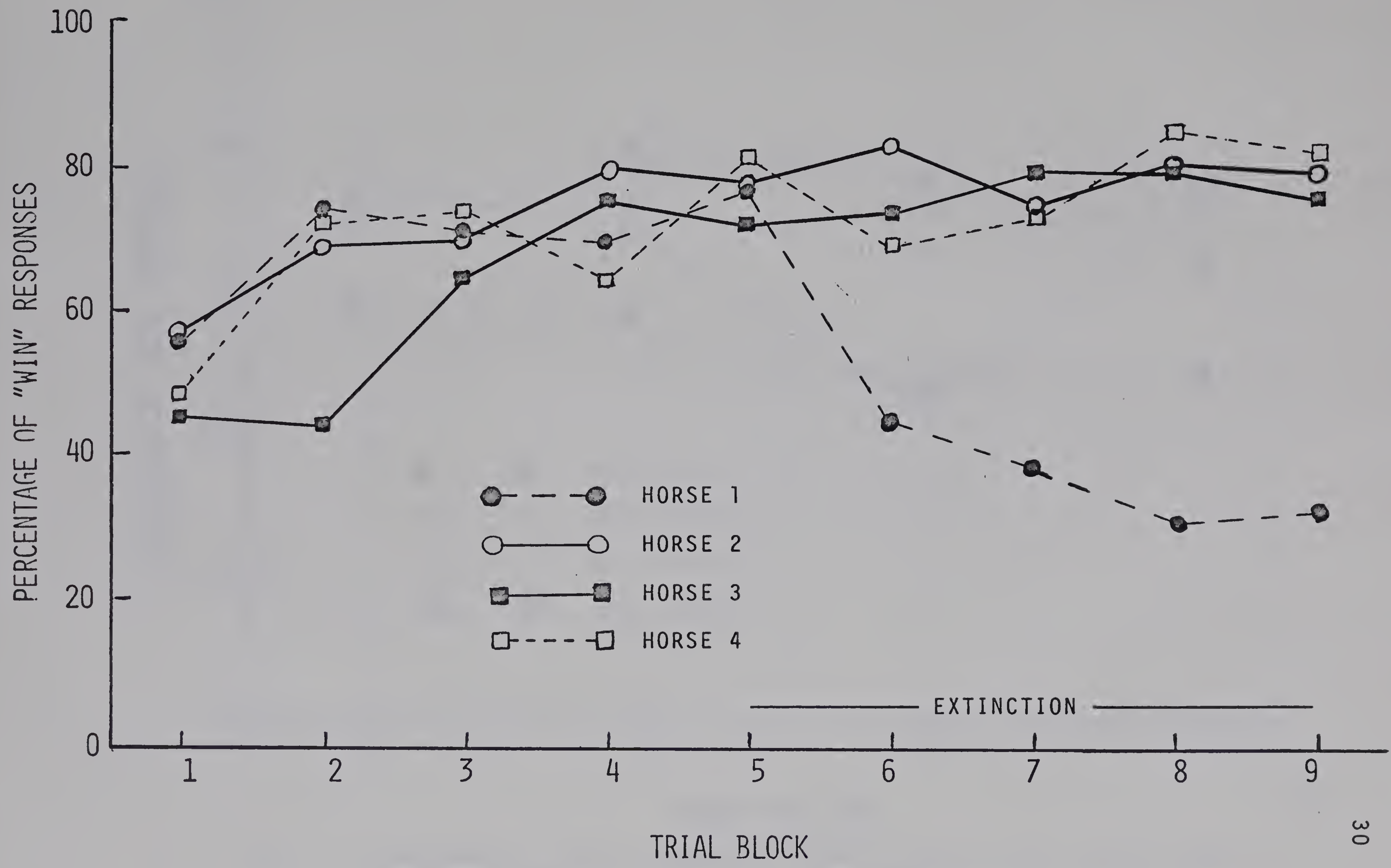


Fig. 1 Acquisition and extinction curves for each horse. Percentage of "win" response for successive five-trial blocks.

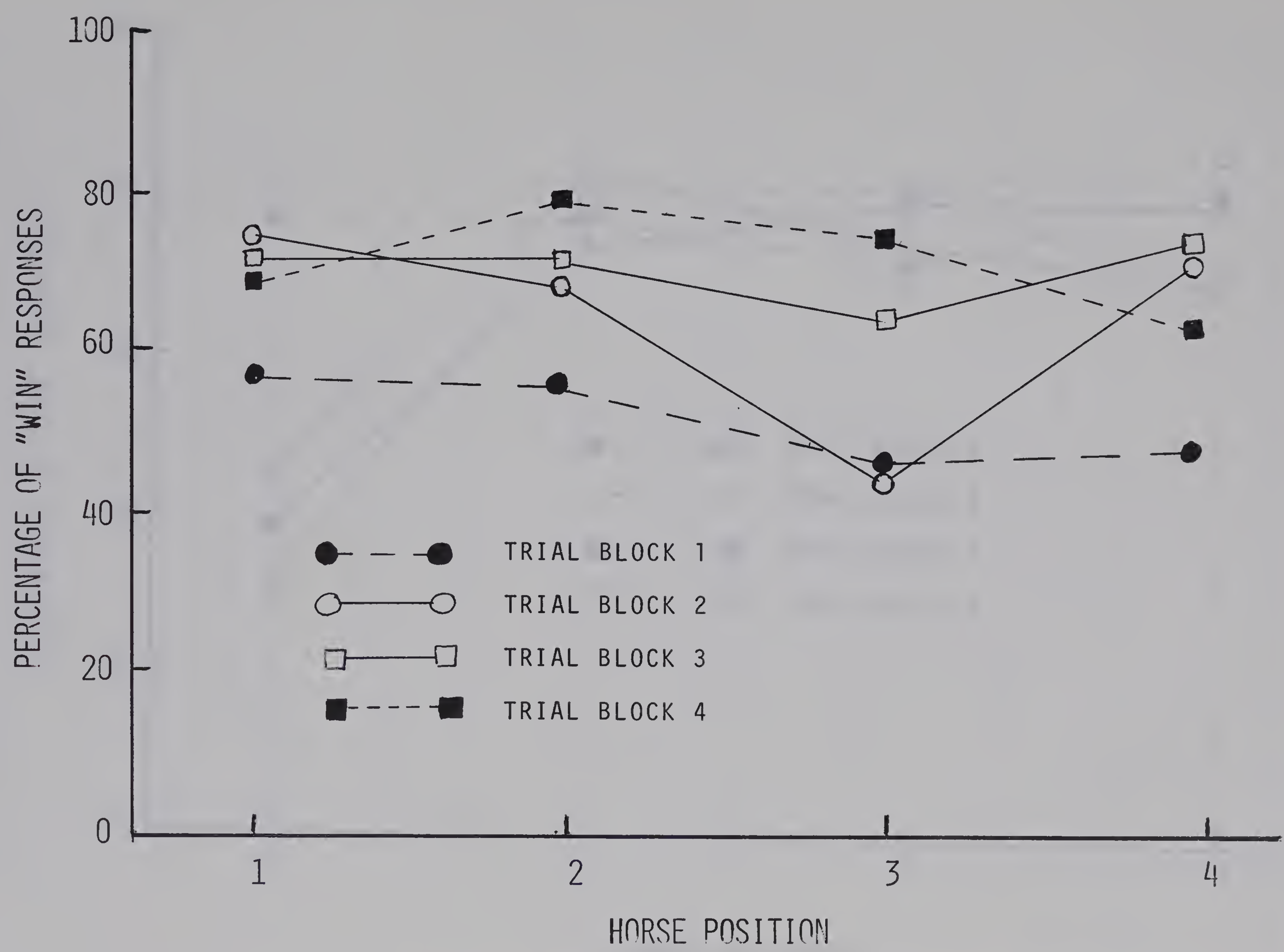
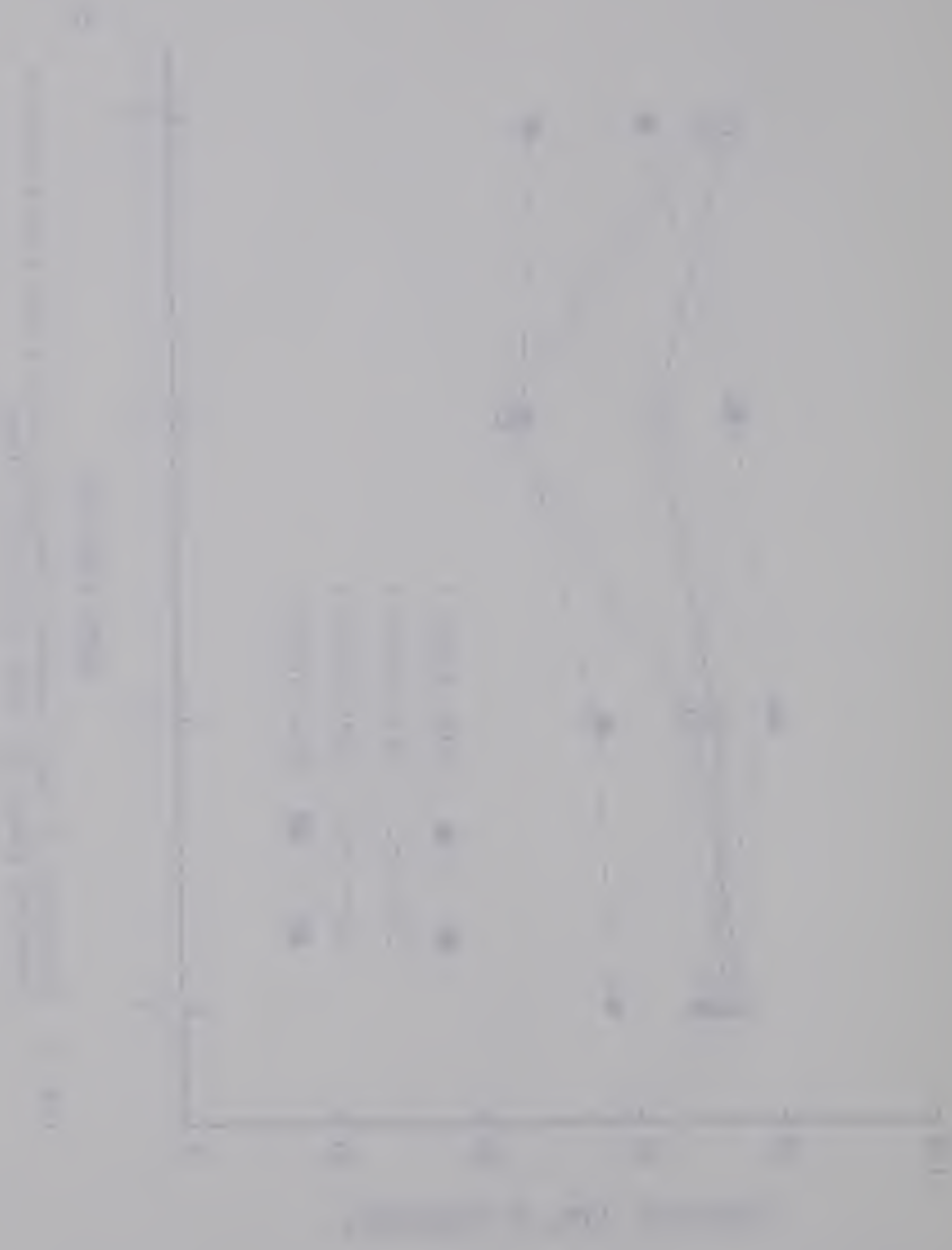


Fig. 2 Gradients of "win"-response frequency during the acquisition or training phase for each five-trial block.



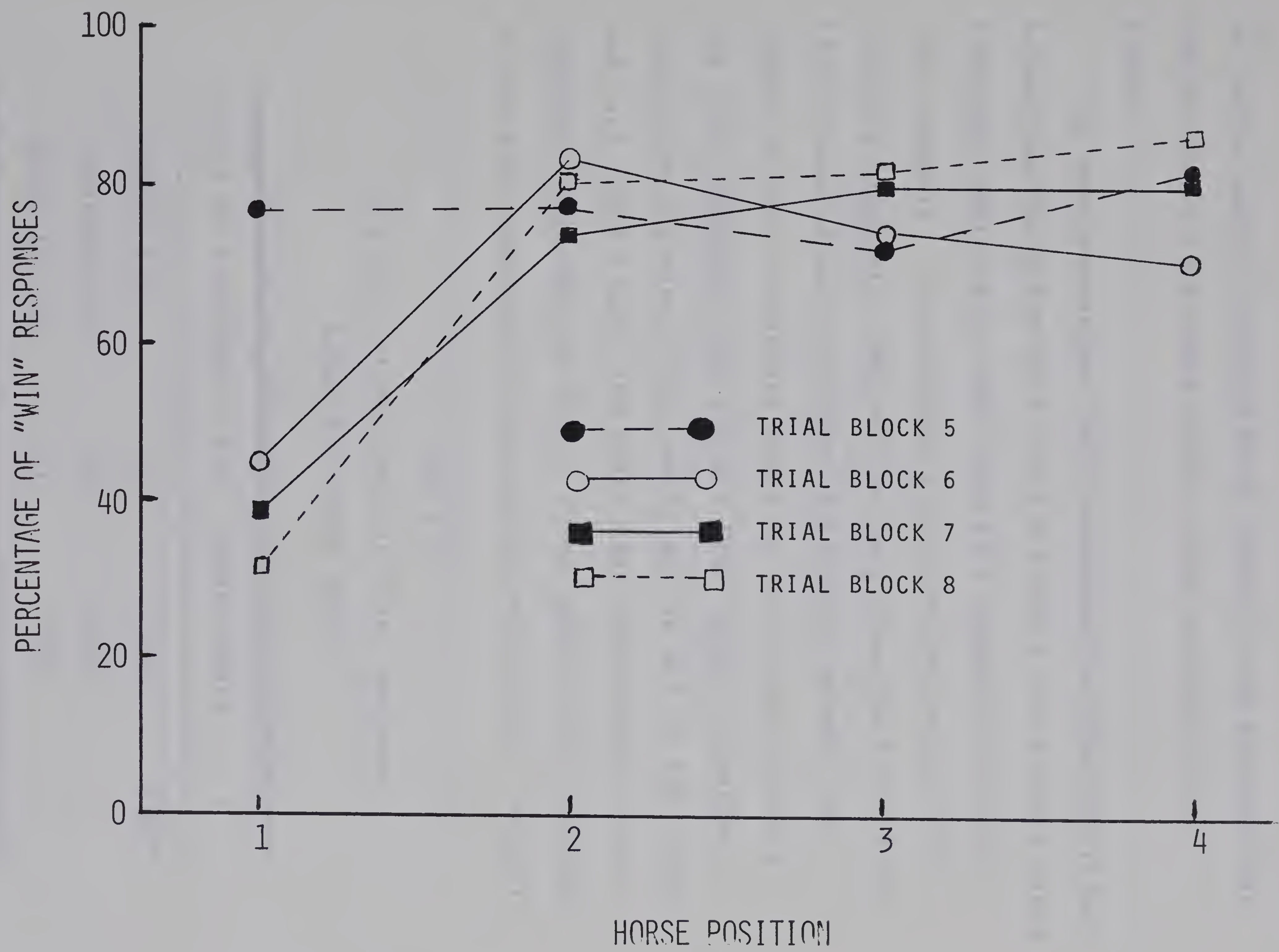


Fig. 3 Gradients of "win"- response frequency during the testing and extinction phase. Data for trial block 9 are omitted.

as can be seen by inspection of Table 1, the data are not too different from those of the three previous trial blocks.

The mean percentage "win" responses for the individual horses and the grand mean of 52.2 for the first trial block indicates that the Ss were initially responding more or less randomly. A randomized blocks design analysis of variance (Edwards, 1962) of the data from the first trial block revealed no significant difference between the number of "win" responses given to each horse (Table 2). The "win" response rate for all four horses increased during the training trials until by the end of the fourth and last trial block, the grand mean percentage of "win" responses had risen to 72.8. A low rate of win responses to horse #3 appeared in the second trial block. Analysis

Table 2

Analysis of Variance of "Win" Response

Rates for Trial Block 1

Source of Variation	d.f.	Mean Square	F
Horses (H)	3	1.60	0.89*
Subjects (S)	19	0.96	
Error (S x H)	57	1.79	

*P > .05

of variance revealed that the difference was significant for the second trial block (See Table 3), but it had disappeared by the third trial block (See Table 4). Inspection of Table 1 shows clearly that Horse #3 was different from the other three, but that the others were not different from each other.

Table 3

Analysis of Variance of "Win" Response Rates for Trial Block 2

Source of Variation	d.f.	Mean Square	F
Horses (H)	3	9.47	5.15*
Subjects (S)	19	2.34	
Error (S x H)	57	1.84	

*$P < .01$

Table 4

Analysis of Variance of "Win" Response Rates for Trial Block 3

Source of Variation	d.f.	Mean Square	F
Horses	3	0.90	0.58*
Subjects	19	1.37	
Error (S x H)	57	1.56	

*$P > .05$

Beginning with trial block 6, the second extinction trial block, the mean percentage of "win" responding dropped rapidly for horse #1 and continued to drop through blocks 7 and 8. It appeared to reach an asymptote by trial block 8 at about the 30% level, which is somewhat higher than the objective "win" rate of 20% for the extinction trial blocks. The extinction trial block means for Horse #1 were examined using Duncan's New Multiple Range Test in order to determine the range through which the decline in "win" responding was significant. Only the differences between the first extinction trial block and the remaining four trial blocks reached significance ($P < .05$), suggesting that the extinction was virtually complete by the end of the second extinction trial block.

As can be seen in Table 1, the mean "win"-bet percentages for the remaining three horses in the last trial block more closely approximated the objective win rates than did that for horse #1. No other systematic trends in extinction are evident in the data.

"Win"-bet frequencies for the extinction trial blocks were evaluated by the analysis of variance summarized in Table 5. The obtained significant treatment and trials effects and significant interaction were anticipated as a consequence of the probability matching to the objective differences in the win rates for the horses.

Table 5

Analysis of Variance of "Win"

Responses for Extinction Trial Block 5-9

Source of Variation	d.f.	Mean Square	F
Trials (T)	4	3.12	3.67*
Horses (H)	3	71.50	21.67*
Subjects (S)	19	1.93	
H x T	12	5.74	5.68*
S x T (error T)	76	.85	
S x H (error H)	57	3.30	
S x H x T (error H x T)	228	1.01	

*$P < .01$

Of interest for determining a possible gradient of generalization of extinction was the effect on the rate of "win" response to horses #2, #3, and #4 when horse #1 was partially extinguished. A series of orthogonal comparisons was made on the treatment main effect and the horses by trials interaction (see Table 6). The object of the comparisons was to determine the range through which the treatment of interaction effects were significant. Since the generalization of extinction would be expected to result in a gradient of decreasing response decrement with distance from the extinguished

Table 6

Tests of Significance for

Orthogonal Comparisons 1, 2, and 3

Source of Variation	d.f.	Mean Square	F
Comparison 1			
Horses (H)	1	213.36	48.60*
S x H_1 (error a)	19	4.39	
H x T	4	15.42	14.55*
S x H x T_1 (error b)	76	1.06	
Comparison 2			
Horses	1	.17	.05
S x H_2 (error a)	19	3.25	
H x T	4	1.24	1.63
S x H x T_2 (error b)	76	.76	
Comparison 3			
Horses	1	.98	.43
S x H_3 (error a)	19	2.26	
H x T	4	.57	.47
S x H x T_3 (error b)	76	1.21	

*$P < .01$

stimulus, the comparisons were selected so as to detect differences in that direction only. Three comparisons were made. The first of these compared the "win"-response rate to horse #1 with the mean of the "win"-response rates to horses #2, #3, and #4 and is significant (see Table 6) as expected since horse #1 was objectively winning less often than the others and since the overall analysis of variance (see Table 5) showed a significant treatment ("Horses") effect. The second comparison, the crucial one for demonstrating possible generalization of extinction, compared Horse #2 with the mean for horses #3 and #4. Neither this comparison nor the third comparison, comparing horse #3 with horse #4, was significant. If generalization had occurred, both comparisons 2 and 3 should have been significant, with the rate for the horse on the left being less than that for the mean of the remaining horses on the right.

As can be seen in Fig. 1, the Ss quickly solved the objective probability-matching to all horses in the training trials and continued to do so into the extinction or generalization trials for horses #2, #3 and #4. The matching in extinction to horse #1, the extinguished or 20% "win"-rate horse, approached the objective win rate fairly quickly but was not as accurate as to the other horses. After only ten trials (i.e., two trial blocks) to the extinguished horse, the "win"-response rate had

been reduced from 77% to 45% and by the ninth trial block it had been reduced to 33%, somewhat above the objective "win"-rate of 20%.

Inspection of the individual protocols revealed that only one of the 20 _S_s failed to make the discrimination at some point during the extinction trials. The discrimination criterion was defined as a "win"-response rate of 40% or less to horse #1 and 60% or more to horse #2. Roughly half of the subjects had made this discrimination by the end of the second extinction trial block and all of these _S_s continued to make the discrimination on the next or subsequent trial blocks. Inspection of the data in acquisition revealed nothing to distinguish those who were slow or failed to achieve the discrimination from those who did achieve it quickly. Further inspection of the protocols was undertaken in order to determine if there were transitory generalization effects at the time each _S_ began making the discrimination. No such effects were found.

Discussion

The data for the present experiment provide no evidence of a gradient of generalization of extinction of a voluntary response in the spatial dimension. Failure to observe the phenomenon in this experiment does not, of course, preclude the possibility that it might be demonstrated under a different set of conditions. Among the factors which might account for the failure of the gradient to appear in the present study are: (1) an interfering "frame of reference" phenomenon, (2) a position preference, (3) rapid discrimination, and (4)a "prepotent win" effect.

In relation to the first reason, Helson and Avant (1967), using instrumentally conditioned responses, and Thomas and Jones (1962), using voluntary verbal responses, have reported a central tendency or "frame of reference" effect in the generalization of acquisition. The result of this tendency is the displacement of the gradient toward the center of the range of values being tested. If an analogous tendency occurred in the present paradigm, it would presumably reduce the number of win responses to a horse nearer the center (i.e. horse #2 or #3) proportionately more than to the actually extinguished end horse. Some slight support for this interpretation lies in the fact that the "win"-response rates for horses #2 and #3 did drop slightly, from 80% to 78% and from 76%

to 73%, respectively, at the beginning of extinction. Furthermore, the "win"-response rate to horse #1 never did drop completely to the objective win probability level of 20%. The "frame of reference" phenomenon, had it occurred in sufficient strength, might even have enhanced the generalization of extinction, but it does not appear to have had much effect on the gradient at all.

Since the initial rates of "win"-responding were at approximately chance levels for all stimuli, there is no evidence to support the second possibility, of position preferences prior to training. A strong bet-"lose" effect did appear to horse #3 in trial block 2, but it disappeared with further training. Even if it had carried over into later trials, it is not clear how it might deter the development of an extinction gradient, at least to horse #2.

The third possibility, that there were transitory generalization effects but that the discrimination was made very rapidly and the effects obscured, is also unsupported by the data. Only eight of the nineteen Ss who had made the discrimination by trial block 9 responded to horse #2 at less than the objective "win"-rate on the trial block in which they first made the discrimination. Eight of the remaining eleven Ss responded at greater than the objective rate. In other

words, it appears that once the Ss recognized the difference between the objective win rates of horses #1 and #2, if anything, they maximized that difference. The contrast was made even greater on the next trial block as is evident from the fact that of the sixteen Ss who made the discrimination before trial block 9, only one responded to horse #2 at less than the objective win rate.

The practice of continuing reinforced trials into the generalization test trials might have curtailed generalization effects by facilitating the development of discrimination. However, other studies have used such trials and found gradients in acquisition. For example, Brown et. al. (1951) used 104 reinforced trials to the central light and interspersed the 24 test trials among them and still got reasonable gradients. Nakamura and Kaswan (1962) also got gradients of acquisition generalization from their procedure using five test trials interspersed among 40 "booster trials" to the CS. Sherman and Knopf (1960) examined the effects of "booster trials" by replicating the experiment of Brown et. al. (1951) using two levels of reinforced trials to the training stimulus. They found that the larger number of such trials resulted in the higher gradient, but that there was no significant difference between the slopes. The relative number of reinforced trials to each of the test stimuli in the present experiment was equal and, therefore,

many times greater than in the above studies. If the non-extinguished stimuli had been presented only often enough to obtain a reliable measure of the response rates to them, as was done in the above studies, the discrimination might not have occurred as rapidly and some generalization effects might have been obtained.

While anyone of the preceding analyses might account for the failure to get a gradient of generalization of extinction, the possibility remains that the phenomenon simply does not exist for this paradigm because of the nature of the voluntary response. There is some evidence supporting this view in acquisition generalization studies. Brown et. al. (1958) noted in their description of the horse-race betting technique that the gradient of generalization in acquisition did not develop as a result of differential heightening from an initial zero baseline of responding, as is the usual case in conditioning studies. The gradient here developed rather as a differential resistance, as a function of space, to the depressing effect on the level of "win"-responding when the win rate was less than chance. The gradient developed from an initial 50% (chance) level of "win"-responding to all stimuli, to an increased level for the central stimulus and a decreased level for the other stimuli. The resulting gradient is a product of this "extinction" of chance "win"-responding. Other studies (Bass, 1958;

Dixon & Wickens, 1961) report similar gradients for which the highest rate of responding to generalized stimuli is chance or only slightly better. The rest of the gradient is a product of the "extinction" of "win"-responding. Dixon and Wickens (1961) noted further that despite the fact that the six peripheral lights were losing predominantly and only the central light was winning predominantly, there was no evidence of a suppression of frequency of "win" bets to the central light. In fact, in all reported studies using this technique, the frequency of "win" responses to the central (high "win"-rate) stimulus is very near the objective win frequency. It appears then, that the objective low "win"-rates do not generalize to the central stimulus. If generalization is taking place in the horse-race-betting paradigm, it appears to be only from the positive or high "win" bet direction.

The basis for the difference between the probability-matching situation, which yields only acquisition generalization, and the more usual conditioning procedures, which yield both acquisition and extinction generalization, may be the fact that the extinction generalization effects in the former are offset by a "prepotent win" effect. That is, although Ss can objectively win by betting "win" on a winner or "lose" on a loser, they seem to prefer to win by betting on a winner. The "prepotent win" effect might account for the

fact that the responding to horse #1 was not reduced to the 20% level and the generalization failed to occur to horses #2 and #3. The fact that S would objectively win most often by betting "win" to horses #2, #3 and #4 would contribute to the Ss' preference for construing only correct "win" bets as successes. The effect would be to keep the "win"-betting up despite the extinction at one of the stimulus points. A different type of response might be used to eliminate the "prepotent win effect". For example, the task could be changed so that Ss are required simply to predict the appearance of one of two colored lights at each of the stimulus points. Presumably Ss would not construe one color as preferable to the other. It would be expected, using this technique, that generalization of extinction could occur because the response bias would be eliminated.

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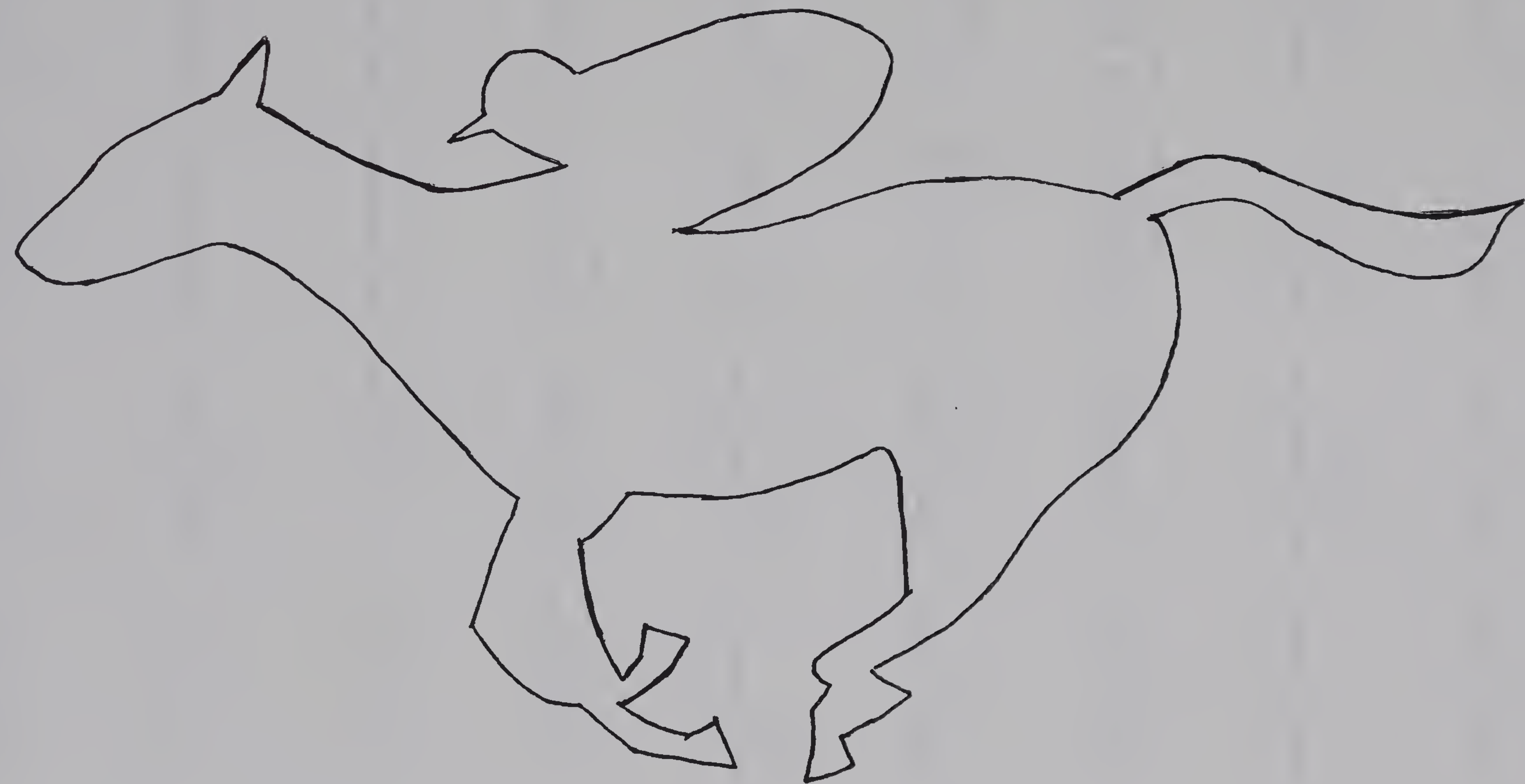
APPENDICES



Appendix A

Pattern used for the cut-out silhouettes of the horses. All horses were facing to the left for all trials and for all subjects.

TRIAL BLOCK

I	II	III	IV	V	VI	VII	VIII	IX
3	4	4	4 L	3	2	4	3	4
1 L	1	2	1	4 L	3 L	3	3	3 L
4	4	2	4	1	1 L	3 L	4 L	3
2	3 L	4	4	3	1 L	4	2 L	1 L
3 L	2	3 L	1	1 L	2	1 L	4	1 L
1	2	3	3	4	4	2 L	1 L	3
3	1	1 L	1	4	1 L	1 L	1 L	1
4 L	1	3	4	2	2	4 L	3	4
4	3	1	1 L	1 L	3	4	1 L	4 L
1	4	3	3	2	3	3	4	2
3	3	4	2	2	2	2	2	4
2	2	2	2	3	4 L	2	2	3
2	2 L	2 L	3	4	4	3	3 L	1 L
1	1	1	3 L	2 L	3	1	1 L	2
2 L	4 L	1	2	3 L	4	1 L	2	4
3	2	4 L	2	3	3	2	4	3
4	1 L	1	3	2	1	3	2	2
2	4	2	4	4	1 L	1 L	1	1 L
1	3	4	2 L	1 L	4	2	4	2 L
4	3	3	1	1 L	2 L	4	3	2

Appendix B

Order of presentation of horses (numbered from S's left) by trial blocks. L indicates that the horse "lost" the race.